Saskatchewan
Agriculture
and Food

ADF

AGRICULTURE DEVELOPMENT FUND

FINAL REPORT

20030459

YIELD, QUALITY AND PRODUCTION ECONOMICS OF COOL AND WARM SEASON ANNUAL FORAGE GRASS SPECIES

Funded by: The Agriculture Development Fund

January 2008

Prepared by: Saskatchewan Forage Council

ADF Project #20030459

Yield, Quality and Production Economics of Cool and Warm Season Annual Forage Grass Species

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Objectives: Comparison of yield, forage quality and production economics of cool season and warm season annual grasses for greenfeed/silage, swath grazing, and simulated grazing in the major cropping zones of Saskatchewan. In study one, Barley (Excel), Oats (CDC Baler), Triticale (AC Ultima) were compared to Golden German foxtail millet, Siberian red foxtail millet, and Crown millet under simulated grazing, silage or swath grazing harvest management for three years at Swift Current, Saskatoon, and Melfort. In study two, Winter wheat (CDC Buteo), Fall rye (Prima), Winter Triticale (Bobcat), Westerwolds ryegrass (Botrus) , Italian ryegrass were compared under simulated grazing at the same sites and years.

Summary Conclusions:

1. When utilized for grazing, the cool-season annual crops (barley, oats, and triticale) produced higher forage yield than warm-season millet crops (Golden German, Siberian foxtail, and Crown millet). The millet crops frequently failed to produce sufficient regrowth to permit simulated grazing harvests. When utilized for silage harvesting or for swath grazing, the cool-season crops produced more forage than millets in most site-years and when averaged over site-years. However, when temperatures were above average in 2006 , the millet crops seeded in June, produced higher yields than the cool-season traditional annual forage crops. Yields were lower at Swift Current (Brown Soil) in 2006.

2. When utilized for grazing, the cool-season annuals had higher Crude Protein (CP) and lower Neutral Detergent Fiber (NDF) concentration than the millet crops. When utilized for swath grazing or silage harvest, millets had 2% higher CP concentration and higher Acid Detergent Fiber (ADF) and NDF than the cool-season annuals.

3. The decline in forage quality from swathing time to the end of October, when swath grazing would typically start, varied from year-to-year. The CP concentration of May seeded barley declined by 3.5% which was the largest average decline observed.

4. Economic returns to producers indicated that cool-season annual crops will generate greater profits to producers than millet crops in all three harvest management systems.

5. Westerwolds ryegrass produced the most forage under simulated grazing and Italian ryegrass the least. Winter wheat produced the highest economic return with Westerwolds ryegrass producing the second highest returns. Winter triticale produced the highest CP and lowest ADF and NDF concentrations when averaged over all site-years and harvests. However, the forage quality of all five species was sufficient to permit good gains by grazing animals.

Section 1: Comparison of cool and warm season annual grasses for forage.

Objective: Comparison of yield, forage quality and production economics of cool season and warm season annual grasses for greenfeed/silage, swath grazing, and simulated grazing in the major cropping zones of Saskatchewan.

Sites: 1) Swift Current - SPARC - brown soil zone
2) Saskatoon - Saskatoon Research Centre - dark brown soil zone
3) Melfort - Melfort Research Farm - black soil zone

Species (6): Barley (Excel), Oats (CDC Baler), Triticale (AC Ultima), Golden German foxtail millet, Siberian red foxtail millet, Crown millet.

Seeding dates (2): May 20, June 20

Harvest managements (3): Greenfeed/silage, simulated swath grazing, simulated grazing (3 cuttings)

Experimental design: Randomized complete block design with treatments arranged in a split plot. Main plots were seeding dates (2), and species/harvest management combinations (18) as sub-plots. There were four replications of plots 2.4 X 6 m (varied slightly according to equipment at each site). The double width plot accommodated the simulated swath grazing treatments where half of the plot will be harvested and weighed and the other half was swathed.

Data collected:

Dry matter yield
- Greenfeed/silage - Cut 1 at soft dough; regrowth cut on Sept. 15
- Simulated swath grazing - Cut 1 at soft dough, regrowth on Oct. 30
- Simulated grazing - Clip 1 at boot stage, clip 2 when about 25 cm of growth available, clip 3 in late October, provided that regrowth was sufficient.

Forage quality
- ADF, NDF, ADL, CP estimates
- Sampling done at times of cut described above.
- Four replications were sampled for forage quality and bulked into two samples
- Quality analyses were carried out at the Prairie Feed Resource Centre (PFRC)

Economics of annual forage production

The six different species of annual cool and warm season forages were evaluated for two different planting dates (May 20 and June 20), under three different management systems (grazing, silage and swath grazing) for their economic suitability at three different locations across

Saskatchewan (Swift Current, Saskatoon and Melfort). Saskatchewan Agriculture & Food's *Farm Machinery Custom and Rental Rate Guide* was used to determine operating costs in addition to the actual costs for all inputs. Revenue was calculated using Saskatchewan Agriculture & Food's ten year average market price for annual forages and Canfax's historic market price for barley to determine market price for silage and then calculated based on the actual yields collected at the various locations. Total costs varied by management strategy at each location and included land preparation, inputs such as herbicide application and fertilization, as well as any costs associated with the method of harvest. As expected, costs were higher for those systems that involved mechanical harvest as compared to the more extensive swath grazing and grazing harvest systems.

From these total cost and revenue values, a net return per acre was calculated for each species, for both planting dates, under the three different management systems, at each location, for each of the three years. In addition, a three year average net return was calculated for each species, at both planting dates under the three different management systems. Variation in the net returns at the three locations may also be attributed to the different in-crop management that was undertaken. For example, Swift Current included a complete pre- and in-crop herbicide and fertilization program whereas the plots located in Melfort were grown utilizing fewer inputs. These variations in management need to be considered when comparing the average net returns by locations.

Results of Trial 201 – Warm- and Cool-Season Annual Forages

Preliminary analysis of the full data-sets from this project indicated that the harvest management system interacted with all the other management factors studied, i.e. interactions of harvest management systems, species, seeding date, site and year were all highly statistically significant for yield and quality parameters. As these analyses are complex to present and interpret, we decided to analyse and present each harvest management system in its own section.

SWATH GRAZING HARVEST MANAGEMENT

Forage DM yield

Forage DM yield exhibited significant seeding date x species interaction at 7 out of 9 site-years and for the average yield across all site-years (Table 1). The interaction was not significant at Saskatoon 2004 and Melfort 2005. The traditional cool-season annual forage crops yielded more at the May seeding date than at the June seeding date while the warm-season millets tended to yield similar amount of forage regardless of seeding date. These was confirmed when site mean yields over 3 years were compared. The mean millet species yields were similar across seeding dates while the cool-season crop yield declined when seeded in June (data not shown).

Yields for the Swath Grazing treatments were correlated to the weather data from each location (Table 2). For this analysis, yield data from the May seeding date was correlated to the May through August precipitation total and mean temperature. The yield data from the June seeding date was correlated to the June through September precipitation total and mean temperature. As expected, the warm-season millet crops exhibited a positive yield response to warmer temperatures across the site years while the cool-season crops exhibited a negative response. This result indicates that warm-season millet crops for forage will become better adapted under future warmer climates. However, under current climatic conditions at these locations in Saskatchewan, cool-season annual crops continue to provide greater biomass for swath grazing.

Table 1. DM yield (Mg ha^{-1}) of 3 cool-season and 3 warm-season annual crops harvested for swath grazing at 3 locations for 3 years in Saskatchewan.

Crops	Swift Current						Saskatoon				
	2004		2005		2006		2004	2005		2006	
	May	June	May	June	May	June	mean	May	June	May	June
Barley	8.16	9.10	7.55	6.09	5.61	3.26	9.04	9.48	6.85	8.14	7.11
Oats	11.16	10.30	7.53	5.89	4.83	3.06	8.59	9.11	8.54	7.08	6.26
Triticale	13.03	9.71	9.20	6.40	5.58	3.16	8.29	11.19	8.90	7.05	6.38
Crown millet	6.61	6.81	7.10	6.54	4.40	4.90	4.28	7.27	3.91	6.46	7.37
German millet	8.54	6.18	5.61	5.46	3.64	3.97	3.84	8.50	5.02	10.05	8.41
Siberian millet	6.59	6.35	5.72	5.42	4.26	4.59	3.97	6.81	5.19	7.08	7.94
SE	0.30		0.34		0.32		0.48	0.50		0.51	

	Melfort					Mean	
	2004		2005	2006			
	May	June	mean	May	June	May	June
Barley	8.30	9.51	8.60	9.27	6.30	8.42	7.14
Oats	8.47	9.20	9.26	9.48	7.09	8.60	7.37
Triticale	7.68	8.78	10.70	9.34	7.46	9.39	7.48
Crown millet	5.13	3.09	5.72	6.84	8.61	6.01	5.66
German millet	4.54	2.72	4.85	8.80	8.14	6.62	5.26
Siberian millet	4.81	2.46	5.04	8.36	9.08	5.89	5.52
SE	0.24		0.39	0.42		0.15	

Table 2. Monthly precipitation and mean temperature at three sites for three years of the Cool- and Warm-Season Annual Crop trials

Month	Swift Current			Saskatoon			Melfort		
	2004	2005	2006	2004	2005	2006	2004	2005	2006
	precipitation (mm)								
May	84	24	35	27	28	40	34	37	63
June	66	99	97	80	160	108	66	165	74
July	61	21	31	75	54	32	56	70	39
August	72	52	21	74	54	30	54	99	45
September	27	41	62	21	74	118	52	97	119
	temperature (°C)								
May	8.6	9.7	12.3	8.5	10.2	11.7	6.9	9.1	11.1
June	12.9	14.7	16.2	13.1	14.4	16.2	12.7	13.9	16.7
July	17.6	18.3	21.0	17.3	17.5	20.0	16.5	17.1	18.3
August	15.3	16.5	19.1	14.6	15.4	18.0	13.5	14.5	17.1
September	12.0	12.3	12.6	10.7	11.3	12.2	10.6	11.2	11.4

Forage Quality

The crude protein (CP) concentrations of millet crops harvested for swath grazing were higher than that of barley, oats or triticale when averaged over 9 site-years (Table 3). Crown millet, Golden German millet and Siberian millet were 1.5-2 % higher in CP than the traditional annual crops. Similar results were observed at Swift Current 2004 and 2006, Saskatoon 2005 and Melfort 2005. The seeding date x species interaction was significant at Saskatoon 2004 and Melfort 2004. In both cases, the interaction can be attributed to the higher CP concentration for the millet crops for the June 20 seeding while the CP of barley, oats and triticale tended to be similar for both seeding dates. The interaction was not significant when the CP concentrations were averaged over 9 station-years. There was no significant difference due to species at Swift Current in 2005 and Saskatoon in 2006. These results suggest that frequently the CP concentration of annual millet crops harvested for swath grazing will be greater than traditional annual crops but this difference will not occur consistently at all sites and in all years.

There was a significant seeding date x species interaction for ADF concentrations at 6 site-years, i.e. Swift Current 2004, Swift Current 2005, Saskatoon 2004, and Melfort 2004-2006, as well as for the mean over 9 site-years (Table 4). At Swift Current 2004, barley exhibited the highest ADF and German millet the lowest at both seeding dates so the interaction was caused by the inconsistent response of the other species to seeding date. At Swift Current 2005, barley had the highest ADF and Crown millet the lowest at both seeding dates. At the May seeding date, the ADF concentration of oats, triticale, German millet, and Siberian millet were intermediate to barley and Crown millet but at the June seeding date, these species were similar to Crown millet. At Saskatoon 2004, the barley ADF concentration was lowest at both seeding dates but German millet had the highest concentration at May seeding and oats had the highest concentration at June seeding. At Melfort 2004, oats had the highest and Crown millet the lowest ADF concentration at May seeding but Siberian millet was the highest and barley the lowest at June seeding. At Melfort 2005, oats exhibited the highest ADF at both seeding dates, while Siberian millet exhibited the lowest concentration at May seeding and barley the lowest at June seeding. At Melfort 2006, the seeding date x species interaction was due to the differing response of German millet to seeding date while the other species had similar ADF concentrations across seeding dates. Based on the average over 9 site-years, the ADF concentration data suggest that crown millet quality will be the best choice and triticale the poorest quality when seeded in May. When seeded in June however, triticale or Crown millet would have the best quality and Siberian millet the lowest.

Table 3. Crude Protein (%) of 3 cool-season and 3 warm-season annual crops used for swath grazing at three locations for three years in Saskatchewan.

Crops	Swift Current			Saskatoon			
	2004	2005	2006	2004		2005	2006
				May 20	June 20		
Barley	12.6	16.1	16.5	11.4	12.7	8.7	9.8
Oats	13.8	17.3	18.4	10.2	13.2	8.4	10.5
Triticale	11.4	15.4	15.3	13.3	10.9	7.6	10.4
Crown Millet	16.1	16.0	19.4	13.2	14.4	11.2	10.9
German millet	13.9	16.3	17.4	13.0	15.3	11.8	10.9
Siberian millet	15.1	15.8	18.5	11.0	13.4	11.4	10.7
SE	0.3	NS	0.8		0.4	0.5	NS

	Melfort				Mean
	2004		2005	2006	
	May 20	June 20			
Barley	12.4	12.5	10.4	15.3	12.6
Oats	11.1	12.3	9.0	14.3	12.7
Triticale	12.3	11.7	8.9	14.2	11.9
Crown millet	13.5	16.3	10.8	13.1	14.1
German millet	14.0	16.5	11.8	14.0	14.0
Siberian millet	13.2	16.2	11.7	15.1	13.9
SE		0.7	0.6	0.8	0.2

Table 4. Acid Detergent Fiber (%) of 3 cool-season and 3 warm-season annual crops used for swath grazing at 3 locations for 3 years in Saskatchewan.

Crops	Swift Current					Saskatoon			
	2004		2005		2006	2004		2005	2006
	May	June	May	June	mean	May	June	mean	mean
Barley	51.8	42.4	38.7	34.9	35.4	30.0	28.6	38.2	29.0
Oats	41.1	36.4	35.3	30.2	30.5	32.0	41.3	34.0	34.3
Triticale	45.1	34.6	36.9	30.3	34.6	34.2	34.5	34.0	33.4
Crown millet	42.8	36.7	29.5	29.2	28.6	35.3	36.3	29.6	34.8
German millet	40.3	33.4	32.2	30.9	33.3	38.0	39.3	32.2	35.3
Siberian millet	43.7	38.4	33.6	29.9	29.7	37.4	38.6	32.3	38.3
SE	0.7		0.6		1.3	1.5		1.3	1.2

	Melfort						Mean	
	2004		2005		2006			
	May	June	May	June	May	June	May	June
Barley	36.4	31.5	33.5	26.1	29.0	32.8	36.1	32.8
Oats	45.4	34.6	39.0	38.7	38.2	37.9	37.2	34.8
Triticale	37.8	35.7	35.1	32.8	37.0	35.6	37.4	32.7
Crown millet	36.1	34.1	36.0	32.8	35.8	36.7	34.7	32.7
German millet	37.8	37.3	38.0	35.8	40.3	34.9	36.9	34.2
Siberian millet	38.7	37.8	31.8	34.3	40.8	39.7	36.5	35.0
SE	1.3		1.0		0.9		0.5	

There was significant seeding date x species interactions for NDF concentration at 4 site-years, i.e. Swift Current 2004, Swift Current 2005, Saskatoon 2004, and Melfort 2006 as well as the mean over 9 site-years (Table 5). At Swift Current 2004 and 2005, barley exhibited the highest NDF concentrations at both seeding dates. However, the lowest NDF concentration was oats in May seeded 2004 and German millet in May seeded 2005 while the lowest concentration was found for triticale in June seeded of both years. In contrast barley exhibited the lowest NDF concentration for both seeding dates at Saskatoon 2004 and Melfort 2006. The highest NDF concentration varied among site-years and seeding dates with German millet (twice) and Crown millet (twice). Based on mean over 9 site-years, barley had the lowest NDF concentration while Crown millet exhibited the highest for both May and June seeding. The significant seeding date x species interaction for mean NDF concentration is due to the unstable response of triticale to seeding date compared to the other species. These data suggest that barley intake would be favoured by cattle over Crown millet and that triticale should be seeded late to reduce NDF concentrations and improve intake.

The seeding date x species interaction was significant for lignin concentration at 6 site-years, i.e. Swift Current 2004-2006, Saskatoon 2004, Saskatoon 2005 and Melfort 2004, and for the mean over all 9 site-years (Table 6). Barley frequently exhibited the highest lignin concentration while German millet or Crown millet was frequently the lowest. The interaction resulted from the unstable response of other species, such as triticale, to the seeding date where its values were similar at Swift Current 2006 between the two seeding dates but differed between seeding dates at Swift Current 2004, Swift Current 2005, Saskatoon 2004, Saskatoon 2005 and Melfort 2004. Based on the lignin concentrations, German millet will have better nutritive value than barley or Crown millet.

Table 5. Neutral Detergent Fiber (%) of 3 cool-season and 3 warm-season annual crops used for swath grazing at 3 locations for 3 years in Saskatchewan.

Crops	Swift Current					Saskatoon			
	2004		2005		2006	2004		2005	2006
	May	June	May	June	mean	May	June	mean	mean
Barley	72.2	63.4	66.3	65.0	64.5	44.1	44.5	62.3	50.0
Oats	61.7	58.1	62.0	58.8	58.8	51.4	66.3	59.1	61.5
Triticale	67.0	53.0	64.7	58.4	64.9	52.9	49.4	58.0	57.2
Crown millet	67.2	63.2	60.8	63.7	62.2	59.8	63.4	59.4	61.7
German millet	64.0	56.0	59.1	62.8	62.1	65.6	61.6	59.0	63.1
Siberian millet	67.0	62.1	62.1	63.2	58.7	62.6	58.9	60.0	62.4
SE	0.8		0.6		1.5	2.0		NS	1.7

	Melfort				Mean	
	2004	2005	2006			
	mean	mean	May	June	May	June
Barley	58.2	53.0	50.7	58.3	58.4	57.2
Oats	69.1	65.2	65.0	65.1	62.3	61.6
Triticale	63.2	58.2	62.7	60.4	62.2	56.9
Crown millet	68.0	66.1	68.6	68.7	64.7	63.1
German millet	63.8	65.5	70.0	64.0	64.2	61.4
Siberian millet	64.9	61.7	70.0	68.2	63.2	62.1
SE	1.0	1.4	1.2		0.7	

Table 6. Lignin (%) of 3 cool-season and 3 warm-season annual crops used for swath grazing at three locations for three years in Saskatchewan.

Crops	Swift Current						Saskatoon				
	2004		2005		2006		2004		2005		2006
	May	June	May	June	May	June	May	June	May	June	mean
Barley	7.0	4.8	6.4	4.7	6.4	4.9	4.0	4.1	6.3	4.3	10.4
Oats	5.1	3.7	5.6	3.5	4.3	3.9	3.5	4.6	4.1	3.8	8.4
Triticale	5.8	3.9	6.4	4.3	5.3	5.5	4.6	3.9	5.5	3.5	12.2
Crown millet	4.8	4.1	5.1	4.3	4.3	3.7	4.9	4.3	3.5	3.1	12.9
German millet	3.6	2.5	5.5	3.1	5.9	3.5	2.6	2.5	2.5	2.6	8.6
Siberian millet	4.9	4.0	6.3	3.7	4.3	4.0	4.1	3.8	3.7	3.7	12.7
SE	0.1		0.2		0.2		0.3		0.3		0.8

	Melfort				Mean	
	2004		2005	2006		
	May	June	mean	mean	May	June
Barley	6.0	4.4	3.6	4.4	6.3	4.8
Oats	5.9	3.2	3.7	4.6	5.1	4.3
Triticale	6.0	3.9	3.2	5.1	6.2	4.8
Crown millet	4.2	3.7	3.3	4.7	5.2	5.0
German millet	5.3	6.8	2.3	3.4	4.5	3.8
Siberian millet	4.8	6.7	2.6	4.4	5.4	5.0
SE	0.5		0.1	0.2	0.1	

Decline in forage quality in Swath

The decrease in CP varied widely among site-years with a large decline for all species in May seeded Saskatoon 2005 and zero losses at June seeded Swift Current 2004 (Table 7). There was no significant difference among species for CP decline at Saskatoon 2006 and Melfort 2005. This suggests that weathering losses in CP are variable due to the environment and that species is less important than weather conditions. There were some situations where it appeared that CP concentration had increased as denoted by negative values in Table XX+4. This is likely an artifact of the fact that other soluble DM constituents were leached from the plant material in the swath resulting in a CP concentration increase instead of loss. Overall 9 site-years, the loss of CP was greater for traditional crops than the millet species at May seeding but were similar among all the crops at June seeding.

The increase in ADF concentration from swathing until late October exhibited seeding date x species interaction at 6 site years, i.e. Swift Current 2004, Swift Current 2005, Saskatoon 2004, Saskatoon 2006, Melfort 2004 and Melfort 2006 (Table 8). There was no consistent pattern to the seeding date x species interaction. When averaged over all 9 site years, there was no significant interaction or species effect on ADF concentration increase. This suggests that it is difficult to predict the performance of these species in maintaining nutritive value in the swath as it is currently impossible to forecast the weather that far in advance.

The increase in NDF concentration from swathing until late October exhibited seeding date x species interaction at 4 site years, i.e. Swift Current 2005, Saskatoon 2004, Melfort 2004 and Melfort 2005 (Table 9). There was no consistent pattern to the seeding date x species interaction. There was a significant species effect at the other 5 site-years but no consistent pattern among the species. When averaged over all 9 site-years, there was no significant seeding date x species interaction or species effect on NDF concentration. This result suggests that it will be difficult to predict intake of these species for swath grazing without prior knowledge of the late-summer and fall weather that the swathed crops will be exposed

The increase in lignin concentration from swathing until late October exhibited seeding date x species interaction at 3 site years, i.e. Swift Current 2005, Saskatoon 2005, and Melfort 2005 (Table 10). There was no consistent pattern to the seeding date x species interaction at these 3 site-years. There was a significant species effect at the other 6 site-years but no consistent pattern. For example, the increase in lignin concentration German millet ranged from the highest values at Swift Current 2004, Swift Current 2006, and Melfort 2004 to the lowest value at Melfort 2006 (Table XX+7). There was a significant species effect when the lignin increase was averaged over all 9 site-years. Siberian millet lignin concentration increased the most (2.2%) in the swath while oat lignin concentration increased the least. As two functional groups, the millet species and traditional annual crops did not differ in the lignin concentration increase in the swath.

Table 7. Decline in CP (%) of 3 cool-season and 3 warm-season annual crops used for swath grazing at three locations for three years in Saskatchewan.

Crops	Swift Current				Saskatoon				
	2004		2005	2006	2004		2005		2006
	May	June	mean	mean	May	June	May	June	mean
Barley	1.6	0.1	2.9	3.0	1.9	0.6	12.0	4.8	3.8
Oats	0	-0.9	3.9	5.6	3.6	0.7	9.5	4.6	4.9
Triticale	-0.7	0	4.1	3.0	1.2	0.3	8.6	3.0	1.4
Crown millet	4.0	1.1	3.0	1.4	1.2	1.9	5.1	5.6	3.1
German millet	-0.3	-0.2	3.0	1.5	1.3	3.2	3.7	6.8	3.4
Siberian millet	-0.1	-0.2	2.4	-1.1	0.8	1.3	5.1	3.1	3.5
SE	0.6		0.5	1.0	0.5		1.2		NS

	Melfort				Mean	
	2004		2005	2006		
	May	June	mean	mean	May	June
Barley	1.4	-2.2	1.3	-0.5	3.5	1.1
Oats	1.1	-2.0	0.0	0.4	3.4	1.8
Triticale	-1.7	-2.2	-0.3	-3.2	1.7	0.4
Crown millet	-0.1	2.9	-0.2	-1.1	2.5	1.2
German millet	1.5	0.6	0.3	0.3	1.7	2.0
Siberian millet	0.3	2.0	0.9	-1.3	1.5	0.9
SE	1.1		NS	0.7	0.3	

Table 8. Increase in Acid Detergent Fiber (%) of 3 cool-season and 3 warm-season annual crops for swath grazing at 3 locations for 3 years in Saskatchewan.

Crops	Swift Current					Saskatoon				
	2004		2005		2006	2004		2005	2006	
	May	June	May	June	mean	May	June	mean	May	June
Barley	13.7	4.1	3.9	2.1	3.4	3.4	3.6	6.5	-2.1	4.8
Oats	8.0	6.2	4.8	2.7	4.3	-2.4	6.4	-0.4	5.3	4.7
Triticale	7.2	3.2	-0.3	2.0	4.1	1.4	-0.3	2.1	7.2	3.0
Crown millet	12.9	5.6	4.8	2.6	6.4	2.6	4.1	-4.1	6.5	2.1
German millet	5.8	2.1	6.6	2.0	9.6	3.2	5.8	-2.2	5.2	3.5
Siberian millet	10.0	5.1	7.2	2.7	5.5	3.8	4.9	-4.0	6.4	5.7
SE	0.9		0.6		1.2	1.5		1.7	1.7	

	Melfort					Mean
	2004		2005	2006		
	May	June	mean	May	June	
Barley	5.4	-3.0	5.3	8.3	8.2	4.5
Oats	12.3	0.2	5.2	8.5	7.7	4.7
Triticale	6.1	2.5	3.7	10.8	8.3	3.9
Crown millet	2.1	4.8	4.8	5.7	9.2	4.3
German millet	4.1	4.6	4.2	6.2	2.1	4.1
Siberian millet	2.5	6.0	3.0	6.2	8.4	4.4
SE	1.9		NS	1.2		NS

Table 9. Increase in NDF (%) of 3 cool-season and 3 warm-season annual crops used for swath grazing at three locations for three years in Saskatchewan.

Crops	Swift Current				Saskatoon			
	2004	2005		2006	2004		2005	2006
	mean	May	June	mean	May	June	mean	mean
Barley	8.9	6.4	4.3	4.1	3.9	4.3	13.8	0.1
Oats	9.7	7.7	7.6	9.0	-4.2	7.9	5.7	7.6
Triticale	5.9	0.0	7.1	8.6	4.4	0.8	10.3	7.4
Crown millet	9.4	8.4	6.2	11.3	-0.9	3.7	2.5	4.4
German millet	5.0	8.4	4.2	12.9	8.2	5.5	6.0	4.0
Siberian millet	9.1	9.9	7.8	8.8	6.0	2.2	3.1	3.8
SE	0.7	1.1		1.5	1.9		2.0	1.9

	Melfort					Mean
	2004		2005	2006		
	May	June	mean	May	June	
Barley	8.6	2.8	6.4	4.2	10.7	6.2
Oats	18.8	9.1	8.2	10.0	10.8	8.2
Triticale	13.9	6.4	4.4	13.5	10.5	7.3
Crown millet	5.5	9.0	6.8	7.4	15.6	6.9
German millet	10.0	7.8	8.5	7.9	5.2	7.2
Siberian millet	7.5	10.1	5.5	6.4	10.5	6.7
SE	2.5		2.0	1.4		NS

Table 10. Increase in lignin (%) of 3 cool-season and 3 warm-season annual crops used for swath grazing at three locations for three years in Saskatchewan.

Crops	Swift Current				Saskatoon			
	2004	2005		2006	2004	2005		2006
	mean	May	June	mean	mean	May		mean
Barley	1.1	2.0	0.6	2.0	1.1	1.7	0.7	6.0
Oats	0.8	2.1	1.0	1.2	0.9	0.2	-0.4	4.7
Triticale	0.4	2.4	0.9	1.8	1.0	1.8	-0.3	7.5
Crown millet	1.2	2.7	1.6	1.9	1.3	-1.0	-0.9	8.7
German millet	0.3	3.4	1.1	2.5	0.4	-0.8	0.2	4.9
Siberian millet	1.2	3.6	1.2	2.0	0.8	-0.6	-0.1	8.7
SE	0.2	0.2		0.2	0.2	0.4		0.9

	Melfort				
	2004	2005		2006	Mean
	mean	May	June	mean	
Barley	1.0	2.1	-0.2	1.6	1.8
Oats	2.3	0.3	-0.2	1.1	1.4
Triticale	2.1	0.4	-0.3	2.1	1.9
Crown millet	0.3	0.2	-0.4	1.5	1.8
German millet	3.5	0.3	-0.4	0.7	1.6
Siberian millet	3.0	-0.3	0.2	1.5	2.2
SE	0.7	0.3		0.2	0.2

Economics

The Table below (Table 11) details the economic analysis for the six species seeded at two dates at Swift Current when used in a swath grazing system. The vast majority of these species realized a positive average net return, with the exception of June seeded Golden German Foxtail Millet and June seeded Siberian Red Foxtail. The highest average net return in a swath grazing system at Swift Current was realized on May seeded Triticale, while the lowest average net return was the June seeded Golden German Foxtail Millet.

Table 11. Economic returns to Swath Grazing of six annual forage crops grown at Swift Current

		2004	2005	2006	Average
Species	Seeding Date	Net Return ($/ac)	Net Return ($/ac)	Net Return ($/ac)	Net Return ($/ac)
Barley	May	43.90	33.61	0.50	$26.00
	June	57.49	12.28	[illegible]	$8.78
Oats	May	82.78	28.56	[illegible]	**$31.95**
	June	70.26	6.44	[illegible]	$8.50
Triticale	May	116.97	60.20	2.64	**$59.94**
	June	67.93	19.36	[illegible]	**$15.00**
German Millet	May	43.87	2.81	[illegible]	**$6.27**
	June	9.43	0.65	[illegible]	[illegible]
Siberian Foxtail	May	21.46	7.42	[illegible]	**$3.44**
	June	18.04	3.05	[illegible]	[illegible]
Crown Millet	May	25.76	32.00	[illegible]	**$15.22**
	June	28.70	23.84	[illegible]	**$12.63**

Under the swath grazing harvest system in Saskatoon (Table 12), all species at both seeding dates realized positive average net returns over the three growing seasons, with only a few negative returns realized in the 2004 growing season for the warm season forages. May seeded Triticale attained the highest average net return, with a net gain of $80.23 per acre over the three growing seasons. Similar to the silage harvest system, the lowest average net return was attained again by June seeded Golden German Foxtail Millet, with a net return of $15.29 per acre.

Table 12. Economic returns to swath grazing six annual forage crops grown at Saskatoon.

Species	Seeding Date	2004 Net Return ($/ac)	2005 Net Return ($/ac)	2006 Net Return ($/ac)	Average Net Return ($/ac)
Barley (Excel)	May	$93.14	$80.20	$59.25	**$77.53**
	June	$48.33	$42.11	$44.26	**$44.90**
Oats (CDC Baler)	May	$78.28	$70.00	$39.01	**$62.43**
	June	$40.70	$61.78	$27.18	**$43.22**
Triticale (AC Ultima)	May	$87.08	$107.67	$45.95	**$80.23**
	June	$35.69	$74.27	$36.11	**$48.69**
Golden German Foxtail Millet	May	$6.28	$63.42	$84.50	**$51.40**
	June	($27.51)	$12.76	$60.63	**$15.29**
Siberian Red Foxtail	May	($1.18)	$41.84	$43.99	**$28.22**
	June	($3.92)	$18.19	$56.78	**$23.68**
Crown Millet	May	$14.01	$53.00	$39.70	**$35.57**
	June	($2.07)	$4.05	$52.93	**$18.30**

The only negative returns seen under a swath grazing harvest system at Melfort (Table 13) were for June seeded Golden German Foxtail Millet and June seed Siberian Red Foxtail in 2004. All average net returns for all six species were positive. The highest average net return was again for May seeded Triticale at $98.36 per acre, while the lowest average net return at Melfort under the swath grazing harvest system was $33.11 per acre for June seeded Golden German Foxtail Millet.

Table 13. Economic returns to swath grazing six annual crop species at Melfort.

Species	Seeding Date	2004 Net Return ($/ac)	2005 Net Return ($/ac)	2006 Net Return ($/ac)	Average Net Return ($/ac)
Barley (Excel)	May	$79.08	$84.53	$92.97	**$85.53**
	June	$98.88	$84.46	$53.10	**$78.81**
Oats (CDC Baler)	May	$76.77	$97.02	$91.36	**$88.38**
	June	$89.66	$81.88	$59.96	**$77.17**
Triticale (AC Ultima)	May	$71.62	$126.90	$96.55	**$98.36**
	June	$89.82	$108.58	$72.60	**$90.33**
Golden German Foxtail Millet	May	$18.75	$27.32	$83.57	**$43.21**
	June	($5.54)	$27.42	$77.44	**$33.11**
Siberian Red Foxtail	May	$38.76	$36.11	$80.22	**$51.70**
	June	($3.22)	$30.35	$94.08	**$40.40**
Crown Millet	May	$37.42	$42.05	$62.61	**$47.36**
	June	$9.88	$52.88	$91.77	**$51.51**

Conclusions -Swath grazing

1.The cool-season annual crops produced higher swath grazing yields than the millets in most site-years. However, in growing seasons with warmer-than-average temperatures, warm-season millets seeded in June will produce more biomass than the traditional cool-season annual forages.

2. The CP concentration of the millets was 2% higher than that of the cool-season annuals. ADF and NDF concentrations were higher for millets than for the cool-season annuals. Golden German millet was lower in lignin concentration than the cool-season annual crops.

3. The decline of forage quality during the swath conservation period (from swathing to the end of October) varied from site-year to site-year. When averaged over nine site-years, the largest decline in CP was observed from May-seeded barley at 3.5%. There was no significant difference among species for increasing ADF or NDF concentration.

4. The average net returns to producers were twice as much for cool-season annual crops as for millet crops.

SIMULATED GRAZING HARVEST MANAGEMENT

Forage DM yield

When harvested to simulate grazing, there were significant seeding date x species interaction for first cut yield at eight of nine site-years and for the mean yield averaged over all nine site years (Table 14). The interaction stems from two different forage yield responses to the environment. At Swift Current 2005, Saskatoon 2006, and Melfort 2006, one of the cool-season annual crops was the highest yielding species at the May seeding while one of the warm-season crops was lowest; then on of the warm-season crops was the highest yielding species at the June seeding while a cool-season species was the lowest yielding forage crop. At Saskatoon 2004, Saskatoon 2005, Melfort 2004 and Melfort 2005, one of the cool-season annual crops was the highest yielding crop and one of the warm-season annual crops was the lowest yield crop at both seeding dates. At Swift Current 2006, Crown millet was the highest yielding crop while oats was the lowest yielding crop at both seeding dates. At Swift Current 2004, there was no interaction and German millet was the highest yielding annual crop while triticale was lowest yielding crop. When averaged over all nine site-years, barley produced the highest forage yields and Siberian millet the lowest at the May seeding date. Oats produced the highest forage yields at the June seeding date and Crown millet the lowest at the June seeding date.

The 2006 year was 2-3 ◦C warmer at all three sites than the previous two years (Table 2), especially in May, June and July. This environment was more favourable to the warm-season millet species seeded in June such that Crown millet was the highest yielding species in Swift Current, Siberian was the highest yielding species at Saskatoon, and German millet was the highest yielding species at Melfort. In the cooler growing seasons of 2004 and 2005, the cool-season species, oats and barley, were generally higher yielding than the warm-season species especially at the Saskatoon and Melfort locations.

The second cut forage yield (Table 15) data reflects the characteristics of greater regrowth potential of cool-season species compared to warm-season millet species. Crown millet produced regrowth more frequently than the other two millet species. The best regrowth of millet crops was observed at all three sites in 2006 which was a year of warmer growing conditions. When averaged over all site-years, the cool-season species produced more regrowth than the warm-season millet crops.

Table 14. First cut forage yield (kg/ha) of 3 cool-season and 3 warm-season crops harvested for simulated grazing at 3 locations for 3 years in Saskatchewan.

Crops	Swift Current					Saskatoon					
	2004	2005		2006		2004		2005		2006	
	mean	May	June	May	June	May	June	May	June	May	June
Barley	4534	6351	3599	2113	2154	7416	5064	4527	3291	6780	2722
Oats	5496	4531	2089	1304	1128	5424	2755	7251	6314	4210	2408
Triticale	4293	5040	2315	1336	1517	6074	3953	5565	2552	5087	2132
Crown millet	5095	3129	5425	4031	2519	3882	2044	3554	2276	4095	3495
German millet	7044	2628	4111	2477	1791	4221	2738	4206	4701	3495	4812
Siberian millet	5219	2895	4300	3215	2355	3283	3388	4487	3119	4094	5083
SE	301	390		257		411		252		266	

	Melfort						Mean	
	2004		2005		2006			
	May	June	May	June	May	June	May	June
Barley	5998	9282	5996	9451	8328	3305	5801	4804
Oats	6688	11459	8070	9025	6613	3980	5560	4911
Triticale	5305	8994	5249	8370	7251	2761	5131	3989
Crown millet	5163	2853	2358	4180	4072	5237	3912	3699
German millet	4687	2798	3736	5021	3032	7253	3957	4465
Siberian millet	4669	2585	2833	5514	3303	5625	3774	4135
SE	360		324		297		125	

Table 15. Second cut forage yield (kg/ha) of 3 cool- and 3 warm-season crops harvested for simulated grazing at 3 locations for 3 years in Saskatchewan.

Crops	Swift Current						Saskatoon					
	2004		2005		2006		2004		2005		2006	
	May	June	May	June	May	June	May	June	May	June	May	June
Barley	1216	1239	326	325	1326	132	NA	NA	1445	477	0	192
Oats	205	1056	2159	1696	2051	1207	NA	NA	768	723	1111	412
Triticale	536	2477	1252	786	2372	790	NA	NA	904	696	656	377
Crown millet	1029	0	767	0	381	1279	NA	NA	1116	0	1175	961
German millet	0	0	1051	0	614	1648	NA	NA	472	0	1239	0
Siberian millet	0	0	428	0	253	1178	NA	NA	108	0	1087	0
SE	129		171		138		--		172		106	

	Melfort						Mean	
	2004		2005		2006			
	May	June	May	June	May	June	May	June
Barley	1627	0	NA	NA	0	254	660	291
Oats	3721	0	NA	NA	371	212	1154	589
Triticale	2714	0	NA	NA	218	326	961	606
Crown millet	0	0	NA	NA	328	0	533	249
German millet	0	0	NA	NA	458	0	426	183
Siberian millet	0	0	NA	NA	448	0	258	130
SE	93		--		40			

First Cut Forage Quality

There was significant seeding date x species interaction for 7 out of 9 site-years and for the mean over site-years for CP concentration at first cut (Table 16). The pattern for this interaction was not consistent across those 7 site-years. At Swift Current 2005, the cool-season annual crops had higher CP concentration than the warm-season millet crops when seeded in May or June. At Swift Current 2006 and Saskatoon 2005, the cool-season crops had higher CP concentration than warm-season crops at the May seeding but were similar at the June seeding date. At Saskatoon 2004 barley and Siberian millet CP concentrations were unaffected by seeding date, while the CP concentration of the other crops were higher at the June seeding date compared to May. At Melfort 2004, the cool-season crops had lower CP concentration when June-seeded than May-seeded while the warm-season crops had higher CP when June-seeded. At Melfort 2005, the cool-season crops had lower CP when June-seeded while the warm-season crops had similar CP concentration across seeding dates. At Melfort 2006, the CP concentration was highest for triticale and lowest for barley when seeded in May. However, at the June seeding date, the cool-season crops were all higher in CP concentration than the warm-season crops. When averaged over all 9 site-years, the cool-season crop CP concentration was lower at the June seeding date compared to the May seeding date, while it was similar across seeding dates for the warm-season millet crops.

There was significant seeding date x species interactions for 8 out of 9 site-years and for the mean over site-years for ADF concentration at first cut (Table 17). The pattern of the interaction differs among the sites. At Swift Current, ADF concentration of oats was lowest for all three years but the species with the highest ADF concentration varied among years and seeding dates. At Saskatoon, the ADF concentration of Golden German millet or Siberian millet was highest in most instances while the species with the lowest ADF concentration was for oats about 3 times. At Melfort, the lowest ADF concentration was observed for crown millet (4 times) or barley (2 times while the highest ADF concentration varied among the other species. Based on the overall mean analysis, the ADF concentration was highest for Siberian millet and lowest for Crown millet at both seeding dates. The significant seeding date x species interaction can be attributed to the unstable response of oats and triticale to seeding date while barley, Golden German millet, Crown millet and Siberian millet exhibited similar ADF concentrations at the two seeding dates.

There was significant seeding date x species interactions for all 9 site-years and for the mean over site-years for NDF concentration at first cut (Table 18). As with ADF concentration, the pattern for the NDF concentration interaction differs among sites. At Swift Current, the oat NDF concentration was lowest for all years and seeding dates while the highest NDF concentration was observed for Siberian millet for 5 of 6 instances. At Saskatoon, the oat NDF concentration was the lowest among the species for 4 instances while the Siberian millet NDF concentration was highest for 5 out of 6 instances. At Melfort, the NDF concentration was the lowest for barley in 4 out of 6 instances while the highest NDF concentration varied among the other species. Over all 9 site-years, the mean NDF concentration was highest for Siberian millet for both seeding dates while the lowest NDF was observed for barley at the May seeding date and for oats at the June seeding date. These

data suggest that intake of cool-season oats or barley will be preferred by grazing cattle over the Siberian millet and that this effect will be most pronounced at the Brown soil zone site.
There was significant seeding date x species interaction for 6 out of 9 site-years for lignin concentration but not for the overall mean lignin concentration at first cut (Table GG+4). There was no discernible pattern to the interaction. Based on the overall mean lignin concentration at first cut, we suggest that cool-season species had higher lignin concentration than warm-season millet species.

Table 16. Crude protein (%) at first cut of 3 cool- and 3 warm-season crops harvested for grazing at three locations for three years in Saskatchewan.

Crops	Swift Current					Saskatoon				
	2004	2005		2006		2004		2005		2006
	mean	May	June	May	June	May	June	May	June	mean
Barley	25.3	30.4	26.6	45.2	26.8	19.7	19.7	30.3	21.8	23.3
Oats	22.1	34.0	32.9	47.4	30.9	17.0	23.8	25.6	19.4	23.1
Triticale	24.2	33.7	30.0	40.6	27.7	14.7	17.8	25.5	19.3	25.3
Crown millet	20.4	27.5	21.0	23.4	28.8	16.4	18.3	19.8	19.9	19.7
German millet	15.4	25.1	20.1	20.7	25.8	17.2	18.5	18.8	16.8	20.3
Siberian millet	19.1	25.5	17.9	21.0	22.7	16.6	16.0	18.4	18.0	18.3
SE	0.8	0.7		1.1		0.7		1.3		0.8

	Melfort						Mean	
	2004		2005		2006			
	May	June	May	June	May	June	May	June
Barley	14.8	11.5	14.3	10.6	12.6	28.5	24.1	21.4
Oats	14.2	10.6	11.8	10.3	16.2	26.8	23.3	22.4
Triticale	13.8	9.8	14.8	9.2	19.0	24.1	23.5	20.8
Crown millet	12.5	17.9	13.9	12.3	16.9	20.4	19.0	19.8
German millet	12.5	16.9	11.0	12.7	16.6	20.8	17.5	18.6
Siberian millet	12.1	17.4	14.1	13.0	15.8	21.0	18.0	18.1
SE	0.4		0.5		0.8		0.3	

Table 17. Acid Detergent Fiber (%) at first cut of 3 cool- and 3 warm-season crops harvested for grazing at three locations for three years in Saskatchewan.

Crops	Swift Current					Saskatoon					
	2004	2005		2006		2004		2005		2006	
	mean	May	June	May	June	May	June	May	June	May	June
Barley	28.3	28.8	25.8	22.3	25.1	34.6	32.9	32.5	29.8	26.6	26.6
Oats	27.4	24.1	21.0	21.1	18.3	34.7	27.6	29.3	27.4	31.0	22.7
Triticale	28.3	31.4	26.1	22.5	22.3	40.7	32.6	33.0	33.0	25.0	27.5
Crown millet	27.5	23.4	26.6	22.2	20.0	30.3	29.1	32.1	24.3	28.1	27.9
German millet	32.7	27.3	31.1	25.2	24.2	32.3	34.6	33.6	33.3	31.6	30.5
Siberian millet	33.5	28.4	26.5	25.0	26.4	34.0	34.1	34.9	33.1	33.4	34.0
SE	0.6	0.8		0.3		0.9		1.0		0.6	

	Melfort						Mean	
	2004		2005		2006			
	May	June	May	June	May	June	May	June
Barley	27.2	31.6	31.0	24.6	22.2	28.8	28.2	28.1
Oats	32.3	35.0	31.9	37.9	30.5	29.6	29.3	27.3
Triticale	36.7	33.4	32.1	33.1	30.9	28.4	31.3	29.3
Crown millet	32.0	29.2	25.3	28.8	25.1	26.2	27.3	26.7
German millet	35.4	33.1	32.5	30.5	30.2	31.9	31.2	31.2
Siberian millet	36.1	32.5	26.9	30.6	32.5	33.4	31.8	31.4
SE	1.3		1.1		0.9		0.3	

Table 18. Neutral Detergent Fiber (%) at first cut of 3 cool- and 3 warm-season crops harvested for grazing at 3 locations for 3 years in Saskatchewan.

Crops	Swift Current						Saskatoon					
	2004		2005		2006		2004		2005		2006	
	May	June	May	June	May	June	May	June	May	June	May	June
Barley	45.8	45.8	50.1	47.0	39.3	47.3	57.5	55.6	47.6	49.8	50.0	51.2
Oats	45.3	43.4	42.0	39.9	36.9	37.4	58.1	43.4	42.9	40.4	55.0	41.6
Triticale	48.1	45.0	54.9	49.9	40.1	45.1	64.7	53.7	50.3	53.7	47.8	51.1
Crown millet	51.1	52.4	51.2	58.4	51.2	48.8	56.4	54.8	56.2	48.7	56.6	55.7
German millet	54.8	52.9	52.2	61.7	49.7	49.2	57.2	57.4	54.4	54.8	57.1	55.7
Siberian millet	56.2	53.6	53.4	54.6	51.5	51.2	57.2	57.4	57.5	56.0	60.2	61.2
SE	0.7		1.5		1.2		1.1		1.2		1.1	

	Melfort						Mean	
	2004		2005		2006			
	May	June	May	June	May	June	May	June
Barley	49.6	51.8	55.2	49.3	41.6	56.7	48.5	50.5
Oats	55.1	57.7	53.5	64.7	56.3	54.7	49.5	47.0
Triticale	58.8	52.9	56.2	56.1	53.9	54.4	52.8	51.3
Crown millet	61.7	60.3	60.0	58.7	53.8	57.3	55.4	55.0
German millet	57.1	56.0	63.6	55.8	54.2	58.6	55.6	55.8
Siberian millet	59.5	55.1	51.6	57.5	57.2	59.6	56.0	56.2
SE	1.1		2.7		1.0		0.5	

Table 19. Lignin (%) at first cut of 3 cool-season and 3 warm-season annual crops harvested for grazing at three locations for three years in Saskatchewan.

Crops	Swift Current					Saskatoon				
	2004		2005		2006	2004		2005		2006
	May	June	May	June	mean	May	June	May	June	mean
Barley	2.6	2.4	2.8	2.5	2.3	3.1	2.8	3.4	3.0	3.3
Oats	2.4	2.3	1.9	1.8	3.9	2.8	2.4	3.1	3.6	3.2
Triticale	2.7	2.2	2.5	2.3	2.1	4.0	2.7	3.9	3.4	2.8
Crown millet	2.6	2.8	1.8	2.4	2.0	2.8	2.7	3.1	2.3	3.0
German millet	2.9	2.4	2.4	2.1	2.1	1.9	2.0	2.6	2.4	3.3
Siberian millet	3.1	2.6	2.4	2.3	2.4	2.5	2.7	3.2	2.7	3.4
SE	0.1		0.1		0.3	0.2		0.3		NS

	Melfort					Mean
	2004	2005		2006		
	mean	May	June	May	June	
Barley	2.5	2.7	2.8	2.6	2.6	2.8
Oats	2.5	2.3	4.4	2.2	2.6	2.8
Triticale	3.3	2.4	3.3	3.3	2.2	2.8
Crown millet	2.9	1.8	3.0	1.9	2.0	2.5
German millet	3.1	2.4	2.1	1.8	2.4	2.5
Siberian millet	2.9	1.7	2.8	1.9	2.4	2.6
SE	0.6	0.3		0.1		0.1

Second Cut Forage Quality

There was no second cut harvested under the grazing harvest management treatment at Saskatoon 2004, Melfort 2004 or Melfort 2005 (Table 20). In the six site-years where there was sufficient regrowth for a second cutting, there were significant seeding date x species interactions for CP concentration at five of them. At Swift Current 2005, the CP concentration was lowest for triticale at both seeding dates while the highest CP concentration varied from barley at May seeding to Crown millet at June seeding. At Swift Current 2006, the CP concentration was lowest for barley at both seeding dates while the highest CP concentration varied from Siberian millet at the May seeding to triticale at the June seeding. At Saskatoon 2005, the interaction was due to complete reversal of ranking for CP concentration. Triticale exhibited the highest CP concentration at May seeding and the lowest in June while barley had the lowest concentration in May and the highest in June. Siberian millet did not regrow sufficiently at Saskatoon in 2005 to permit sampling. Averaged over all site-years, the seeding date x species interaction was significant (Table 20). Siberian millet had the lowest mean CP concentration at both May and June seeding while oats had the highest when May seeded and barley the highest when June seeded. The CP concentration at second cut of oats and barley were greater for June seeding than for May seeding. However, it was lower for June seeding of all three millet crops.

The seeding date x species interaction was significant for second cut ADF at four of six site-years and for the mean over site years (Table 21). At Swift Current 2004, crown millet had the lowest ADF concentration at both May and June seeding dates while barley exhibited the highest ADF at May seeding and triticale the highest at June seeding. At Swift Current 2005, oats exhibited the lowest ADF concentration at the May seeding date while triticale had the highest ADF. When seeded in June however, barley had the lowest second cut ADF concentration while crown millet had the highest. At Saskatoon 2005, German millet exhibited the highest second cut ADF concentration at both seeding dates while crown millet exhibited the lowest at May seeding and barley the lowest at June seeding. At Melfort 2006, the lowest ADF concentration was observed for crown millet at both seeding dates while the highest concentration was exhibited by barley at May seeding and by triticale at June seeding. When averaged over six site-years, there was a significant seeding date x species interaction (Table 21). When seeded in May, oats exhibited the lowest second cut ADF concentration while Siberian millet had the highest. When seeded in June however, crown millet exhibited the lowest second cut ADF concentration while triticale had the highest.

The seeding date x species interaction was significant for second cut NDF concentration at five of six site-years and for the mean over site-years (Table 22). At Swift Current 2004, oats exhibited the lowest NDF concentration at both seeding dates while crown millet had the highest at May seeding and triticale had the highest at June seeding. At Swift Current 2005, oats had the lowest NDF concentration and Siberian millet the highest at May seeding while barley had the lowest and Crown millet the highest at June seeding. At Saskatoon 2005, oats had the lowest NDF concentration while German millet had the highest at both seeding dates. At Swift Current 2006, oats had the lowest NDF concentration and Crown millet the highest at both seeding dates. At Melfort 2006, oats had the lowest NDF concentration at both seeding dates while the highest NDF

was observed for barley at May seeding and Siberian millet for June seeding. When averaged over all six site-years, the second cut NDF concentration is lowest for oats at both seeding dates, and greatest for triticale at May seeding and for Crown millet at June seeding (Table 22).

The seeding date x species interaction was significant for second cut lignin concentration at two of six site-years and for the mean over site-years (Table 23). At Swift Current 2005, Siberian millet exhibited the highest lignin concentration at both seeding dates while oats and Crown millet had the lowest levels at May seeding and barley had the lowest level at June seeding. At Swift Current 2006, oats exhibited the lowest lignin concentration at both seeding dates while Siberian millet had the highest level at May seeding and German millet had the highest level at June seeding. There was no significant difference among species at three of the other four site-years. When averaged over all six site-years, there was a significant seeding date x species interaction (Table 23). Siberian millet exhibited the highest lignin concentration at May seeding while German millet was highest at June seeding. Barley exhibited the lowest mean lignin concentration at May seeding while Siberian millet was lowest at June seeding.

Table 20. Crude protein (%) at second cut of 3 cool- and 3 warm-season crops harvested for grazing at three locations for three years in Saskatchewan.

Crops	Swift Current						Saskatoon				
	2004		2005		2006		2004		2005		2006
	May	June	May	June	May	June	May	June	May	June	mean
Barley	24.4	23.6	23.2	34.0	19.9	18.1	NA	NA	26.4	33.5	21.6
Oats	34.7	22.6	20.5	29.0	19.1	16.4	NA	NA	27.3	29.6	27.8
Triticale	23.8	17.0	18.0	20.9	14.5	11.5	NA	NA	28.5	26.1	25.1
Crown millet	19.3	NA	22.8	34.7	11.7	14.2	NA	NA	27.9	30.2	23.5
German millet	NA	NA	21.2	29.8	13.3	13.6	NA	NA	28.1	30.4	23.7
Siberian millet	NA	NA	21.5	30.0	11.0	12.9	NA	NA	NA	NA	25.5
SE	1.0		1.1		1.0		NS		2.6		1.8

	Melfort						Mean	
	2004		2005		2006			
	May	June	May	June	May	June	May	June
Barley	NA	NA	NA	NA	14.9	38.8	22.0	29.6
Oats	NA	NA	NA	NA	27.4	41.0	23.7	27.4
Triticale	NA	NA	NA	NA	30.9	34.2	21.0	22.6
Crown millet	NA	NA	NA	NA	30.8	44.4	22.5	16.8
German millet	NA	NA	NA	NA	26.2	39.8	23.0	15.6
Siberian millet	NA	NA	NA	NA	21.5	35.1	19.5	12.9
SE	NS		NS		1.8		0.8	

Table 21. Acid Detergent Fiber (%) at second cut of 3 cool- and 3 warm-season crops harvested for grazing at 3 locations for 3 years in Saskatchewan.

Crops	Swift Current					Saskatoon				
	2004		2005		2006	2004		2005		2006
	May	June	May	June	mean	May	June	May	June	mean
Barley	28.5	26.2	24.5	16.5	23.8	NA	NA	28.8	28.7	29.2
Oats	27.7	24.3	23.6	23.0	23.2	NA	NA	30.4	32.0	25.1
Triticale	28.0	31.7	29.8	28.7	28.2	NA	NA	31.0	34.4	27.3
Crown millet	27.1	15.7	23.2	30.4	24.4	NA	NA	28.4	30.7	23.8
German millet	NA	NA	28.6	28.0	25.5	NA	NA	34.4	36.0	27.9
Siberian millet	NA	NA	28.5	27.9	26.6	NA	NA	NA	NA	27.6
SE	2.7		1.6		0.2	--		0.9		NS

	Melfort						Mean	
	2004		2005		2006			
	May	June	May	June	May	June	May	June
Barley	NA	NA	NA	NA	29.5	20.5	31.7	26.8
Oats	NA	NA	NA	NA	23.6	18.7	29.4	26.2
Triticale	NA	NA	NA	NA	23.9	23.1	32.5	33.4
Crown millet	NA	NA	NA	NA	17.3	12.4	29.5	24.6
German millet	NA	NA	NA	NA	25.9	21.0	33.8	25.7
Siberian millet	NA	NA	NA	NA	25.0	20.1	34.1	26.7
SE	--		--		0.5		0.4	

Table 22. Neutral Detergent Fiber (%) at second cut of 3 cool- and 3 warm-season crops harvested for grazing at 3 locations for 3 years in Saskatchewan.

Crops	Swift Current						Saskatoon				
	2004		2005		2006		2004		2005		2006
	May	June	May	June	May	June	May	June	May	June	mean
Barley	46.0	42.0	50.3	36.5	49.8	46.8	NA	NA	45.6	43.1	54.8
Oats	35.9	34.8	44.4	40.7	46.3	45.0	NA	NA	41.7	41.7	47.4
Triticale	45.0	50.4	53.4	54.3	53.2	52.2	NA	NA	46.6	49.1	50.8
Crown millet	49.8	44.8	53.8	55.7	58.0	56.6	NA	NA	48.4	48.5	53.4
German millet	NA	NA	55.3	51.6	55.2	51.8	NA	NA	51.5	51.6	56.2
Siberian millet	NA	NA	56.2	52.5	55.1	56.0	NA	NA	NA	NA	52.5
SE	0.9		1.6		0.5		--		1.5		1.8

	Melfort						Mean	
	2004		2005		2006			
	May	June	May	June	May	June	May	June
Barley	NA	NA	NA	NA	56.5	42.2	44.1	39.0
Oats	NA	NA	NA	NA	43.2	35.7	42.4	36.2
Triticale	NA	NA	NA	NA	45.4	44.7	47.9	45.6
Crown millet	NA	NA	NA	NA	50.1	42.6	46.4	56.1
German millet	NA	NA	NA	NA	47.9	40.4	47.5	53.0
Siberian millet	NA	NA	NA	NA	52.8	45.3	47.7	56.0
SE	--		--		0.9		0.7	

Table 23. Lignin (%) at second cut of 3 cool- and 3 warm-season crops harvested for grazing at three locations for three years in Saskatchewan.

Crops	Swift Current					Saskatoon			
	2004	2005		2006		2004		2005	2006
	mean	May	June	May	June	May	June	mean	mean
Barley	3.3	2.7	1.7	3.4	4.2	NA	NA	6.0	7.1
Oats	4.0	2.4	1.9	2.6	2.8	NA	NA	7.8	6.1
Triticale	3.0	3.1	2.3	3.5	3.8	NA	NA	6.5	3.8
Crown millet	2.2	2.4	2.7	5.4	3.3	NA	NA	6.1	4.0
German millet	NA	2.7	2.2	5.2	8.7	NA	NA	8.7	4.7
Siberian millet	NA	3.6	3.1	9.2	2.9	NA	NA	NA	3.7
SE	0.2	0.1		0.8		--		--	--

	Melfort					Mean	
	2004		2005		2006		
	May	June	May	June	mean	May	June
Barley	NA	NA	NA	NA	3.3	3.5	3.9
Oats	NA	NA	NA	NA	2.4	3.8	3.0
Triticale	NA	NA	NA	NA	2.6	3.6	3.7
Crown millet	NA	NA	NA	NA	2.3	3.8	3.8
German millet	NA	NA	NA	NA	2.8	4.7	6.5
Siberian millet	NA	NA	NA	NA	2.6	5.0	2.9
SE	--		--		--	0.3	

Economics

The economic potential of the six different species under a grazing system at Swift Current is shown in Table 24. As can be seen from the results below, Golden German Foxtail Millet, Siberian Red Foxtail and Crown Millet all realized positive average net returns for the three years for both seeding dates, with Crown Millet attaining the highest average net return per acre of the three warm season species. In comparison, Barley, Oats and Triticale realized positive average net returns for the May seeding date but realized marginally negative net returns when seeded in June. Oats seeded in May had the highest average net return under the grazing system at Swift Current, while Triticale seeded in June had the lowest average net return under the grazing system at Swift Current.

Table 24. Economic returns from six annual crops grown for grazing at Swift Current.

Species	Seeding Date	2004 Net Return ($/ac)	2005 Net Return ($/ac)	2006 Net Return ($/ac)	Average Net Return ($/ac)
Barley	May	$53.36	$53.06	($13.08)	**$31.11**
	June	$32.50	$8.35	($43.87)	($1.01)
Oats	May	$65.55	$67.68	($15.21)	**$39.34**
	June	$36.77	$3.53	($45.85)	($1.72)
Triticale	May	$47.17	$47.16	($5.63)	**$29.57**
	June	$37.40	($6.63)	($40.91)	($3.38)
German Millet	May	$54.67	($6.29)	($21.92)	**$8.79**
	June	$51.68	$1.47	($25.38)	**$9.26**
Siberian Foxtail	May	$25.49	($9.84)	($12.03)	**$1.21**
	June	$26.54	$7.94	($20.03)	**$4.62**
Crown Millet	May	$43.50	$5.03	$9.61	**$19.38**
	June	$30.85	$32.85	($11.36)	**$17.45**

The economic analysis for the six species under a grazing system in Saskatoon is shown in Table 25. All six species realized positive average net returns for both seeding dates under a grazing system. The highest average net return in a grazing system at Saskatoon was realized by May seeded Barley at $68.48 per acre, while the lowest average net return was attained with June seeded Crown Millet at only $4.19 per acre over the three growing seasons.

Table 25. Economic returns from six annual crops grown for grazing at Saskatoon.

Species	Seeding Date	2004 Net Return ($/ac)	2005 Net Return ($/ac)	2006 Net Return ($/ac)	Average Net Return ($/ac)
Barley	May	$79.56	$56.29	$69.59	**$68.48**
	June	$36.73	$16.18	($0.77)	**$17.38**
Oats	May	$38.58	$88.85	$38.33	**$55.25**
	June	($10.06)	$70.96	($7.19)	**$17.92**
Triticale	May	$56.68	$67.90	$53.29	**$59.29**
	June	$18.06	$9.27	($5.57)	**$7.25**
German Millet	May	$15.87	$30.23	$29.86	**$25.32**
	June	($11.13)	$30.64	$31.27	**$16.93**
Siberian Foxtail	May	$4.85	$31.76	$41.02	**$25.88**
	June	$6.75	$4.88	$39.23	**$16.95**
Crown Millet	May	$19.79	$37.57	$47.10	**$34.82**
	June	($13.66)	($6.02)	$32.26	**$4.19**

The highest average net returns for the entire trial across all locations were realized under a grazing system in Melfort, with May seeded Oats leading the highest average net return at $113.38 per acre (Table 26). The lowest average net return under a grazing system in Melfort was seen for May seeded Golden German Foxtail Millet with an average return of $32.35 per acre over the three growing seasons.

Table 26. Economic return to grazing six annual crops grown at Melfort.

Species	Seeding Date	2004 Net Return ($/ac)	2005 Net Return ($/ac)	2006 Net Return ($/ac)	Average Net Return ($/ac)
Barley	May	$102.45	$72.75	$110.25	**$95.15**
	June	$134.82	$137.89	$31.64	**$101.45**
Oats	May	$148.43	$105.80	$85.90	**$113.38**
	June	$169.74	$125.43	$38.47	**$111.21**
Triticale	May	$111.20	$61.72	$102.00	**$91.64**
	June	$131.13	$120.79	$25.61	**$92.51**
German Millet	May	$43.44	$29.11	$24.49	**$32.35**
	June	$11.25	$54.76	$96.39	**$54.13**
Siberian Foxtail	May	$49.17	$15.71	$32.28	**$32.39**
	June	$13.43	$66.76	$69.78	**$49.99**
Crown Millet	May	$62.21	$11.49	$48.55	**$40.75**
	June	$22.35	$46.91	$67.15	**$45.47**

Conclusions - Grazing harvest management

1. First cut forage yield was greater for cool-season annual crops than for millet crops, especially when seeded in May.

2. The millet crops frequently did not exhibit sufficient regrowth to permit a second forage yield harvest. At several site-years, they did produce regrowth forage when seeded in May but not when seeded in June.

3. First and second cut CP concentrations were higher and NDF concentrations were lower for cool-season annuals compared to the millet crops. ADF concentrations were similar when averaged over all nine site-years.

4. Economic returns to producers from cool-season annual forage crops were twice as much as those from millet crops when averaged over nine site-years.

Forage DM Yield

There was significant seeding date x species interaction for forage yield at six of nine site-years and for the mean over nine site-years (Table 27). In the 2004 and 2005 growing seasons, one or more of the cool-season annual crops (barley, oats or triticale) generally produced more forage than the millet species at all three sites. In the 2006 growing season however, one of the millet species produced more forage than the cool-season annuals at the June seeding date. For example, Crown millet was the highest yielding species at Swift Current and Siberian millet was the highest yield species at Melfort at the June seeding date. At Saskatoon 2006, German millet was the highest yielding species at the May seeding date while Siberian millet was the highest yielding species at the June seeding date. When averaged over all nine-site years, the millet species were lower yielding the cool-season annual crops at both May and June seeding dates.

When growing season temperatures were cooler in 2004 and 2005, the cool-season annual crops produced more silage yield than the warm-season millet crops. However, in the warmer growing season of 2006, the millet crops produced greater silage yield than the cool-season annuals when seeded in June. June seeding is important for producers who have discovered in May that perennial forage stands will have reduced yield potential due to winter-kill or injury and must make contingency plans for additional annual forage crop production. It would be an interesting question for future research to determine if the long-range Environment Canada forecast (3 months) for temperature could be used to predict whether cool-season annual crops or warm-season annual crops would be most productive in that growing season.

Table 27. DM forage yield (kg/ha) of 3 cool-season and 3 warm-season annual crops harvested for silage at three locations for three years in Saskatchewan.

Crops	Swift Current						Saskatoon			
	2004		2005		2006		2004	2005	2006	
	May	June	May	June	May	June	mean	mean	May	June
Barley	8459	10574	7732	6488	5645	3719	9792	8670	8354	6704
Oats	11657	10299	7712	6873	3288	3467	8147	9592	6920	7141
Triticale	13542	10167	10475	7263	6352	3272	8148	10170	7390	6521
Crown millet	6717	6895	6687	7015	4490	5452	3934	5126	6375	8251
German millet	8316	6461	5290	4982	4805	3812	3050	6696	10595	7151
Siberian millet	6519	6637	6201	5254	4243	4902	3935	5949	6754	8441
SE	427		478		326		538	427	441	

	2004		2005	2006		Mean	
	May	June	mean	May	June	May	June
Barley	5945	9758	9191	9834	5637	8614	7403
Oats	9367	10840	9008	9121	8405	8811	7867
Triticale	8257	8465	10876	9387	6882	9894	7480
Crown millet	5118	2893	5442	6377	8298	5786	5722
German millet	3779	2696	4812	7794	8704	6237	5094
Siberian millet	4736	2336	5446	8110	9070	5978	5562
SE	382		430	580		202	

Forage Quality

The seeding date x species interaction for CP concentration was significant for seven of nine site-years and for the mean over nine site-years (Table 28). At Swift Current 2004, crown millet exhibited the highest CP concentration at both seeding dates while triticale was lowest at May seeding and barley was lowest at June seeding. At Swift Current 2005, barley exhibited the highest CP concentration and Crown millet the lowest at the May seeding date but oats had the highest CP and triticale the lowest at the June seeding date. At Swift Current 2006, triticale exhibited the lowest CP concentration at both seeding dates while oats had the highest at May seeding and Crown millet the highest at June seeding. At Saskatoon 2005, barley had the highest CP concentration at May seeding but the lowest concentration at June seeding. At Melfort 2004, triticale had the lowest CP concentration at both seeding dates while German millet was highest at May seeding and Crown millet was highest at June seeding. At Melfort 2005, oats exhibited the lowest CP concentration and Siberian millet the highest at May seeding while triticale was the lowest CP and German millet the highest CP at the June seeding date. At Melfort 2006, German millet had the lowest CP concentration and oats the highest at May seeding while barley had the highest CP and Crown millet the lowest at June seeding date. The variability from environment to environment for CP concentration was evident in the unstable values. However, triticale frequently exhibited low CP concentration and was the lowest CP at both seeding dates when averaged over 9 site-years. Barley exhibited the highest CP concentration at May seeding while Crown millet was highest at June seeding date. It should be noted however that the instability of CP concentration of Crown millet over environment makes it difficult to predict when it will produce high CP concentrations.

The seeding date x species interaction for ADF concentration was significant for eight of nine site-years but not for the mean over nine site-years (Table 29). At Swift Current 2004 and at Swift Current 2005, Crown millet exhibited the lowest ADF concentration while triticale was the highest at May seeding and German millet the lowest ADF while barley was the highest at June seeding date. At Swift Current 2006, German millet was the lowest in ADF concentration while barley was highest at the May seeding date and Crown millet was lowest in ADF while barley was highest at the June seeding date. At Saskatoon 2005 and Saskatoon 2006, Siberian millet had the highest ADF concentration at both seeding dates while triticale was lowest in ADF at May seeding and barley was lowest at June seeding date. At Melfort 2005 and Melfort 2006, barley had the lowest ADF concentration at both seeding dates while the highest values varied among oats (2005) or German millet and Siberian millet (2006). At Melfort 2004, barley exhibited the lowest ADF concentration and Siberian millet the highest at May seeding while Crown millet was lowest and oats the highest in ADF at June seeding date. The instability in ADF concentration, particularly across soil zones, resulted in no significant seeding date x species interaction for ADF concentration when averaged over nine site-year (Table 29). Crown millet was the lowest overall in ADF concentration while Siberian millet was the highest. These results suggest a soil zone effect on ADF concentration of barley. The mean ADF concentration of barley was 34.4% at Swift Current (Brown soil zone) which was the highest value among the six species test. However, it was 28.5% at Saskatoon (Dark Brown soil) and 26.2% at Melfort (Black soil) which were the lowest values at those sites.

The results for NDF concentration were similar to the ADF concentration discussed above. The seeding date x species interaction was significant at seven of nine site-years but not for the mean over nine site-years (Table 30). Barley NDF concentration was generally highest at highest Swift Current and lowest at Saskatoon and Melfort. It was the lowest NDF concentration for the mean over site-years while Siberian millet exhibited the highest mean NDF.

The seeding date x species interaction for lignin concentration was significant at five of nine site-years and for the mean over nine site-years (Table 31). Generally, barley exhibited the highest lignin concentration, particularly at Swift Current and German millet generally had the lowest lignin concentration. This was also evident in the mean over site-years where German millet exhibited the lowest lignin concentration at both seeding dates.

Table 28. Crude Protein concentration (%) of 3 cool- and 3 warm-season crops harvested for silage at three locations for three years in Saskatchewan.

Crops	Swift Current						Saskatoon			
	2004		2005		2006		2004	2005		2006
	May	June	May	June	May	June	mean	May	June	mean
Barley	14.8	10.7	25.2	19.8	23.2	19.7	12.8	19.4	12.7	14.7
Oats	12.9	14.3	24.0	21.2	24.7	17.8	13.5	17.1	13.7	13.1
Triticale	10.6	11.2	21.9	15.6	19.3	14.2	11.4	15.6	13.2	11.2
Crown millet	18.2	16.5	19.7	17.3	20.4	21.2	15.7	15.5	14.7	12.1
German millet	14.6	13.9	21.2	15.9	20.0	18.5	15.7	16.2	16.8	13.0
Siberian millet	14.6	15.4	20.2	18.2	19.7	15.3	14.2	16.0	14.1	13.0
SE	0.6		0.6		0.9		0.4	1.1		--

	Melfort						Mean	
	2004		2005		2006			
	May	June	May	June	May	June	May	June
Barley	14.8	10.7	11.2	11.0	13.7	17.9	16.3	14.8
Oats	11.7	10.5	8.0	10.0	15.0	14.7	15.7	14.2
Triticale	10.6	9.7	8.4	9.1	15.0	14.6	13.8	12.3
Crown millet	11.6	19.1	10.3	12.0	13.9	14.1	15.4	15.8
German millet	16.1	16.1	10.9	13.1	12.2	16.0	15.5	15.5
Siberian millet	13.4	17.4	12.7	12.7	14.6	16.2	15.4	15.2
SE	0.6		0.4		0.6		0.3	

Table 29. Acid detergent fibre concentration (%) of 3 cool- and 3 warm-season crops harvested for silage at three locations for three years in Saskatchewan.

Crops	Swift Current						Saskatoon				
	2004		2005		2006		2004	2005		2006	
	May	June	May	June	May	June	mean	May	June	May	June
Barley	35.8	38.1	32.8	35.8	34.4	29.3	25.7	34.9	29.8	27.7	24.5
Oats	30.8	31.9	30.4	27.9	26.8	25.1	35.5	33.3	32.9	32.6	27.8
Triticale	37.4	31.8	34.4	28.4	32.8	27.7	32.2	31.4	33.3	27.1	28.1
Crown millet	28.2	31.0	24.1	27.8	24.5	23.5	31.9	34.3	33.4	30.2	29.6
German millet	33.5	30.6	28.4	27.6	23.3	24.5	32.6	36.1	34.7	30.7	28.5
Siberian millet	33.0	33.4	30.1	28.9	24.6	23.9	32.4	37.2	35.2	33.2	32.1
SE	0.8		0.7		0.6		0.5	1.1		0.8	

	Melfort						Mean
	2004		2005		2006		
	May	June	May	June	May	June	
Barley	29.4	31.7	25.0	22.7	21.8	26.4	29.5
Oats	33.3	35.9	33.1	34.0	27.8	31.8	31.5
Triticale	32.2	32.2	28.3	31.4	25.4	27.8	30.7
Crown millet	34.9	29.9	29.0	27.0	29.6	26.8	29.3
German millet	33.4	33.4	31.6	30.3	32.7	32.4	31.0
Siberian millet	37.1	32.2	28.4	30.9	32.1	32.5	31.6
SE	0.9		1.0		0.8		0.2

Table 30. Neutral detergent fibre concentration (%) of 3 cool- and 3 warm-season crops harvested for silage at 3 locations for 3 years in Saskatchewan.

Crops	Swift Current						Saskatoon				
	2004		2005		2006		2004	2005		2006	
	May	June	May	June	May	June	mean	May	June	May	June
Barley	57.0	58.6	57.3	65.4	62.0	59.0	39.5	50.4	45.8	50.2	47.2
Oats	49.5	50.8	54.5	52.0	49.4	50.4	56.7	51.6	52.3	59.4	58.3
Triticale	58.3	49.2	58.5	51.9	59.4	53.4	49.2	47.0	49.3	49.5	50.2
Crown millet	54.2	55.1	52.2	59.0	51.9	52.1	57.7	57.7	55.0	58.2	54.0
German millet	56.9	51.9	57.5	55.7	49.0	50.9	56.3	57.3	53.3	57.2	52.0
Siberian millet	56.3	54.0	58.6	59.9	50.3	50.8	55.5	58.8	53.7	61.0	51.6
SE	1.0		1.3		0.7		0.7	1.2		1.2	

	Melfort					Mean
	2004		2005	2006		
	May	June	mean	May	June	
Barley	50.5	51.8	51.0	41.1	47.3	51.4
Oats	55.9	59.1	59.2	49.3	54.8	54.1
Triticale	50.3	53.0	53.5	45.4	48.2	51.7
Crown millet	63.1	57.9	55.5	57.9	53.6	55.9
German millet	55.9	54.8	56.3	60.0	59.0	55.6
Siberian millet	58.2	55.6	55.0	60.0	58.5	56.4
SE	1.1		--	1.0		0.4

Table 31. Lignin concentration (%) of 3 cool-season and 3 warm-season annual crops harvested for silage at three locations for three years in Saskatchewan.

Crops	Swift Current						Saskatoon			
	2004		2005		2006		2004	2005	2006	
	May	June	May	June	May	June	mean	mean	May	June
Barley	4.4	4.6	3.9	4.4	4.4	3.5	2.9	4.2	4.6	3.2
Oats	3.7	3.3	3.2	2.6	2.9	2.7	3.2	3.9	3.9	3.5
Triticale	4.7	3.6	4.2	3.2	4.1	3.3	3.3	3.9	4.6	4.2
Crown millet	2.8	3.5	2.2	2.9	2.3	2.4	3.2	4.2	3.4	5.0
German millet	2.4	2.5	2.3	1.9	2.0	2.2	2.2	3.1	3.2	2.7
Siberian millet	3.3	3.4	2.5	2.7	2.1	2.1	2.8	3.8	3.1	4.2
SE	0.2		0.1		0.1		0.1	0.1	0.3	

	Melfort				Mean	
	2004	2005	2006			
	mean	mean	May	June	May	June
Barley	3.5	2.8	2.6	2.5	3.8	3.4
Oats	3.2	3.5	3.3	4.1	3.4	3.4
Triticale	3.4	3.4	2.8	3.1	3.8	3.4
Crown millet	3.3	2.9	2.6	3.7	3.0	3.4
German millet	2.6	2.4	2.5	2.7	2.5	2.5
Siberian millet	3.4	3.1	2.6	3.2	3.0	3.1
SE	--	0.2	0.1		0.1	

Economics

The economic analysis below shows the economic potential of the six species when used for silage at the Swift Current location and comparing the two different seeding dates. All species at both seeding dates realized an average net loss when utilized for silage at Swift Current, with the exception of Triticale seeded in May, which had an average net return of $20.89 per acre. The lowest average net return was seen on Golden German Foxtail Millet planted in June resulting in an average net loss of $33.31 per acre over the three growing seasons.

Table 32. Economic return to silage harvesting of six annual forages at Swift Current.

Species	Seeding Date	2004 Net Return ($/ac)	2005 Net Return ($/ac)	2006 Net Return ($/ac)	Average Net Return ($/ac)
Barley (Excel)	May	$14.32	($9.88)	($28.61)	($7.39)
	June	$35.27	($19.70)	($53.15)	($12.53)
Oats (CDC Baler)	May	$41.30	($14.75)	($38.62)	($4.02)
	June	$27.84	($20.06)	($60.05)	($17.42)
Triticale (AC Ultima)	May	$66.25	$14.32	($17.89)	**$20.89**
	June	$32.80	($11.01)	($54.47)	($10.89)
Golden German Foxtail Millet	May	$7.36	($31.85)	($48.12)	($24.14)
	June	($11.02)	($34.07)	($54.84)	($33.31)
Siberian Red Foxtail	May	($4.39)	($21.43)	($38.28)	($21.37)
	June	($3.22)	($28.90)	($42.33)	($24.82)
Crown Millet	May	$1.62	($13.15)	($31.66)	($14.40)
	June	$3.38	($16.57)	($33.10)	($13.43)

Similar results were seen under a silage harvest system in Saskatoon, with May seeded Barley achieving the highest average net return at $36.04 per acre. However, negative average net returns were realized on Golden German Foxtail Millet, Siberian Red Foxtail and Crown Millet. The lowest average net return over the three years was a net loss of $16.60 per acre for June seeded Golden German Millet.

Table 33. Economic return to silage harvest of six annual forage crops at Saskatoon.

Species	Seeding Date	2004 Net Return ($/ac)	2005 Net Return ($/ac)	2006 Net Return ($/ac)	Average Net Return ($/ac)
Barley	May	$63.09	$26.22	$18.82	**$36.04**
	June	$20.10	$5.70	$5.19	**$10.33**
Oats	May	$42.88	$26.63	$1.65	**$23.72**
	June	($1.71)	$12.38	$3.56	**$4.74**
Triticale	May	$43.50	$40.36	$13.01	**$32.29**
	June	$10.23	$20.36	$5.45	**$12.01**
German Millet	May	($18.54)	$8.45	$35.82	**$8.58**
	June	($42.98)	($12.68)	$5.86	($16.60)
Siberian Foxtail	May	($8.16)	$2.58	$5.44	($0.21)
	June	($23.20)	($12.54)	$20.11	($5.21)
Crown Millet	May	($3.69)	$0.87	$6.58	**$1.45**
	June	($20.19)	($14.92)	$22.90	($4.24)

The economic analyses of silage harvest systems for the Melfort location is shown in Table 34. As with the grazing harvest system, the six species under a silage harvest system at Melfort all realized a positive average net return. The only negative net returns were seen for warm season forages in 2004 and 2005. The highest average net return was realized on May seeded Triticale at $53.55 per acre. The lowest average net return was attained by May seeded Golden German Foxtail Millet at $7.65 per acre.

Table 34. Economic return to silage harvesting of six annual forage crops at Melfort.

Species	Seeding Date	2004 Net Return ($/ac)	2005 Net Return ($/ac)	2006 Net Return ($/ac)	Average Net Return ($/ac)
Barley	May	$40.58	$39.53	$48.98	**$43.03**
	June	$62.56	$34.93	$15.87	**$37.79**
Oats	May	$59.04	$29.50	$38.07	**$42.20**
	June	$68.57	$32.65	$35.24	**$45.49**
Triticale	May	$49.19	$63.79	$47.67	**$53.55**
	June	$51.30	$42.38	$29.27	**$40.98**
German Millet	May	($4.45)	($1.37)	$28.74	**$7.65**
	June	($12.97)	$1.73	$40.05	**$9.60**
Siberian Foxtail	May	$11.11	$8.81	$34.52	**$18.15**
	June	($10.47)	$7.61	$46.26	**$14.47**
Crown Millet	May	$18.94	$10.87	$23.89	**$17.90**
	June	($0.91)	$14.37	$43.99	**$19.15**

From the economic analysis of the above data, many of the six species have potential for producers to realize positive net returns under the three harvest systems at the two planting dates for the three locations across the province, with only a few exceptions. All species under a silage harvest system at Swift Current realized negative average net returns, potentially due to increased input costs in combination with environmental conditions, with the exception of May seeded Triticale. In addition, both Golden German Foxtail Millet and Siberian Red Foxtail when seeded in June at Swift Current under a swath grazing harvest system saw marginally negative average net returns. As well, the warm season forages under a silage harvest system at the Saskatoon location realized minimal to negative average net returns over the three growing seasons. All six species seeded at both dates saw strong positive net returns at the Melfort location. These results are most likely attributed to the location within the black soil zone and corresponding environmental conditions.

While this information begins to shed light on the potential economic returns of these forage species, again it is essential that producers use this information only as a guide. Individual forage managers must consider their own costs and potential returns prior to deciding to utilize any of these species within their grazing, silage or swath grazing rotations.

Conclusions - Silage harvest management

1. Similarly to the swath grazing harvest management results, cool-season annual crops produced higher yields than warm-season millet crops. However, in years with warmer-than-normal temperatures such as 2006, June-seeded millet crops produce more forage than cool-season crops.

2. Millet crops exhibited higher CP concentration when seeded in June but higher NDF concentration than cool-season annual crops. ADF concentration was similar when averaged over nine site-years.

3. Economic returns to producers were higher for traditional annual crops when averaged over nine site-years. Returns to silage production at Swift Current were generally negative due to lower yields.

Study 2: Comparison of spring seeded winter annuals for grazing

Sites: 1) Swift Current - SPARC
2) Saskatoon - University of Saskatchewan (Kernen Farm)
3) Melfort - Melfort Research Farm

Seeding date: Late May
Species (5): Winter wheat (CDC Buteo), Fall rye (Prima), Winter Triticale (Bobcat), Westerwolds ryegrass (Botrus) , Italian ryegrass.

Experimental Design: Randomized complete block with four replicates. Plots 1.2 X 6.0 m.

Harvest management: Simulated grazing (clipping).

Data collected:

Dry matter yield: Clip #1 when Westerwolds was headed, clip #2 when approximately 25 cm of regrowth was available, clip #3 in October (an additional clip may be done if justified by growth).

Forage quality: ADF, NDF, ADL, CP
Sampling was done at times of cut described above.

Four reps were sampled for quality and bulked into two samples. Quality analyses carried out at the Prairie Feed Resource Centre (PFRC)

Results

First cut forage yield varied among the five annual crops at all nine site-year combinations and when averaged over all site-years (Table 35). Winter wheat produced the highest forage yields at five site-years while Westerwolds annual ryegrass produced the highest forage yields at three site-years. In contrast, Italian ryegrass produced the lowest first cut forage yields at eight site-years. When averaged over all nine site-years, Winter wheat or Westerwolds ryegrass produced similar first cut forage yields while Italian ryegrass yield was significantly lower.

Table 35. First cut DM forage yield (kg/ha) of five annual forage crops harvested for simulated grazing at 3 sites and 3 years in Saskatchewan.

Year	Site	Winter Triticale	Westerwolds ryegrass	Winter Wheat	Italian ryegrass	Winter rye	SE
2004	Swift Current	2543	3548	3495	2539	3293	197
	Saskatoon	2938	1515	3551	465	3524	270
	Melfort	2358	3131	2850	1799	2752	128
2005	Swift Current	4210	4599	4695	3681	4286	325
	Saskatoon	2912	2386	3122	1656	2815	150
	Melfort	3200	5010	3761	3510	3573	115
2006	Swift Current	1186	1175	1495	727	1637	95
	Saskatoon	2051	2656	2664	1866	1952	84
	Melfort	1762	3872	2200	2070	2334	124
Mean		2573	3099	3092	2035	2907	76

The second cut (regrowth) forage yield varied among the five annual crops at all site-years except Swift Current 2006 and for the mean over site-years (Table 36). Winter wheat produced the most regrowth forage at six site-years while Westerwolds ryegrass produced the most at two other site-years. Winter rye produced the least regrowth forage at four site-years, Italian ryegrass the least at two site-years and Winter triticale the least at two site-years. Averaged over all nine site-years, Westerwolds ryegrass and Winter wheat produced the most regrowth forage while Winter rye produced the least.

Table 36. Second cut DM forage yield (kg/ha) of five annual forage crops harvested for simulated grazing at 3 sites and 3 years in Saskatchewan.

Year	Site	Winter Triticale	Westerwolds ryegrass	Winter Wheat	Italian ryegrass	Winter rye	SE
2004	Swift Current	2109	2330	2671	2374	2505	90
	Saskatoon	3061	2261	3698	1330	2600	325
	Melfort	2937	5404	3610	4510	2915	186
2005	Swift Current	1217	1545	2062	1567	1770	161
	Saskatoon	1545	1283	1750	1184	1239	70
	Melfort	3635	6327	3814	5121	2883	208
2006	Swift Current	396	384	437	412	416	ns
	Saskatoon	2227	1784	2469	1800	1595	172
	Melfort	1469	1536	1885	1379	1000	73
Mean		2066	2539	2489	2186	1880	43

Third cut forage yield response varied among the site-years with only five site-years producing sufficient regrowth to permit harvesting in the fall (Table 37). At Swift Current 2004 and Swift Current 2005, Winter triticale produced the most third cut forage while Italian ryegrass produced the least . In contrast, Italian ryegrass produced the most third cut forage and Winter rye the least at Saskatoon 2005. At Saskatoon 2006 and Melfort 2006, and for the mean over all five site-years Westerwolds ryegrass produced the most third cut forage and Winter rye the least.

Table 37. Third cut DM forage yield (kg/ha) of five annual forage crops harvested for simulated grazing at 3 sites and 3 years in Saskatchewan.

Year	Site	Winter Triticale	Westerwolds ryegrass	Winter Wheat	Italian ryegrass	Winter rye	SE
2004	Swift Current	1728	1366	1115	787	1126	101
	Saskatoon	NA[1]	NA	NA	NA	NA	NA
	Melfort	NA	NA	NA	NA	NA	NA
2005	Swift Current	966	550	743	531	648	77
	Saskatoon	2568	3549	2703	3768	2220	154
	Melfort	NA	NA	NA	NA	NA	NA
2006	Swift Current	NA	NA	NA	NA	NA	NA
	Saskatoon	770	1795	595	1654	217	110
	Melfort	2237	2350	1924	1977	812	54
Mean		919	1066	787	968	558	23

[1] NA - not available due to insufficient regrowth.

Annual total forage yield was greatest for Westerwolds ryegrass at five site-years and Winter wheat at three site-years (Table 38). Italian ryegrass was lowest yielding at four site-years and Winter rye was lowest yielding at another four site-years. When averaged over the nine site-years, Westerwolds ryegrass produced the highest total forage yield and Italian ryegrass the least. Westerwolds ryegrass second lowest in forage production at Swift Current in 2006, a warmer drier year when Winter rye was the highest yielding. This suggests that Westerwolds ryegrass productivity may be sensitive to hot and dry growing seasons. The use of Westerwolds ryegrass as an annual crop for pasture appears quite feasible for most years and locations in Saskatchewan. In contrast, Italian ryegrass should not be recommended for annual pasture due to lower yield potential.

Table 38. Total DM forage yield (kg/ha; sum over 2 or 3 harvests) of five annual forage crops harvested for simulated grazing at 3 sites and 3 years in Saskatchewan.

Year	Site	Winter Triticale	Westerwolds ryegrass	Winter Wheat	Italian ryegrass	Winter rye	SE
2004	Swift Current	6381	7245	7283	5702	6925	172
	Saskatoon	5999	3776	7250	1795	6124	469
	Melfort	5295	8536	6461	6309	5667	218
2005	Swift Current	6395	6695	7500	5780	6706	345
	Saskatoon	7026	7220	7576	6608	6275	301
	Melfort	6835	11337	7575	8631	6457	273
2006	Swift Current	1582	1559	1933	1139	2053	128
	Saskatoon	5049	6236	5729	5321	3766	239
	Melfort	5469	7759	6011	5426	4147	196
Mean		5559	6707	6369	5190	5347	85

Winter triticale exhibited the highest CP concentration at six out of nine site-years while Winter rye was highest at the other three site-years (Table 39). Westerwolds ryegrass exhibited the lowest CP concentration at eight out of nine-site years. When averaged over all nine site-years, Winter rye and Winter triticale had similar and highest CP concentration but Westerwolds ryegrass had the lowest CP concentration. It should be noted however, that the CP of Westerwolds ryegrass was sufficient to permit acceptable gains to cattle grazing this annual pasture.

Table 39. Crude protein concentration (%) of five annual forage crops harvested for simulated grazing and averaged over 2 or 3 harvests per year at 3 sites and 3 years in Saskatchewan.

Year	Site	Winter Triticale	Westerwolds ryegrass	Winter Wheat	Italian ryegrass	Winter rye	SE
2004	Swift Current	26.2	20.5	24.8	22.8	24.6	0.3
	Saskatoon	22.1	17	21.4	20.6	21.3	0.4
	Melfort	16	11.1	14.9	13.7	15	0.6
2005	Swift Current	30.8	29	30	30.9	31.7	0.2
	Saskatoon	31.2	29.2	29.9	30.2	30.6	0.8
	Melfort	13.5	9.4	12.4	11.3	13.1	0.6
2006	Swift Current	17.6	16.5	16.2	18	17.3	0.1
	Saskatoon	30.2	26.5	29.2	30.3	32.6	0.4
	Melfort	18.9	13.1	18.7	17.1	21.1	0.4
Mean		22.9	19.2	22	21.7	23	0.1

Westerwolds ryegrass exhibited the highest ADF concentration over all nine site-years and when averaged over all site-years (Table 40). Winter triticale exhibited the lowest ADF concentration at five site-years while Italian ryegrass was lowest at four site-years. While these data suggest that Westerwolds ryegrass has lower digestibility than the other four annual crops, it should be noted that these ADF concentrations are low due to the immature phenological (growth) stage when they were harvested. Ruminants grazing Westerwolds ryegrass at 23.2% ADF concentration would make acceptable gains on this type of pasture. Using the formula:

Total Digestible Nutrients = 88.9 -(ADF x0.779)

this ADF concentration of Westwolds ryegrass would equivalent to 70.8 % TDN which would be acceptable forage for backgrounding yearling beef cattle or for lactating beef cows. Using the formula to convert the ADF concentration of Winter triticale would result in a TDN of 73.5%.

Table 40. Acid detergent fiber (ADF) concentration (%) of five annual forage crops harvested for simulated grazing and averaged over 2 or 3 harvests per year at 3 sites and 3 years in Saskatchewan.

Year	Site	Winter Triticale	Westerwolds ryegrass	Winter Wheat	Italian ryegrass	Winter rye	SE
2004	Swift Current	25	28.6	26.6	24.3	25.4	0.3
	Saskatoon	18	20.9	18.7	19.3	19.6	0.4
	Melfort	13.8	18	15	14.2	14.7	0.5
2005	Swift Current	19.4	21.6	21	19.3	20.4	0.1
	Saskatoon	28.5	30.7	29	29.3	28.5	0.5
	Melfort	14.7	18	16.6	14.7	15.2	0.3
2006	Swift Current	13.8	16.6	14.6	15.2	14.5	0.2
	Saskatoon	22.6	27	23.3	26	21.2	0.4
	Melfort	22.1	27.1	23.7	20.6	21.6	0.4
Mean		19.8	23.2	21	20.3	20.1	0.1

Winter triticale and Italian ryegrass exhibited the lowest NDF concentration at four site-years each while Italian ryegrass NDF concentration was lowest when averaged over all nine site-years (Table 41). Westerwolds ryegrass exhibited the highest NDF concentration at seven site-years and when averaged over all nine site-years. The NDF concentration can approximate DM Intake as a % of body weight according to:

DM Intake = 120÷NDF%

The mean NDF of Westerwolds ryegrass would result in 3% DMI according to this formula while that of Italian ryegrass would be 3.3% of body weight.

Table 41. Neutral detergent fiber (NDF) concentration (%) of five annual forage crops harvested for simulated grazing and averaged over 2 or 3 harvests per year at 3 sites and 3 years in Saskatchewan.

Year	Site	Winter Triticale	Westerwolds ryegrass	Winter Wheat	Italian ryegrass	Winter rye	SE
2004	Swift Current	41.4	45	43.5	38.1	41.5	0.3
	Saskatoon	27.9	32.6	28.9	30.2	29.7	0.3
	Melfort	27.1	32.1	28.9	29	28	0.5
2005	Swift Current	39	40.7	41.3	36.9	39.6	0.2
	Saskatoon	42.4	47.2	45.6	46.6	43.7	0.7
	Melfort	29.4	31.7	31.9	28.4	30	0.4
2006	Swift Current	28.6	31.4	29	29.4	29.3	0.4
	Saskatoon	42.1	46.7	42.5	44.6	39.8	0.6
	Melfort	44.4	49.7	46.5	40.2	44.3	0.8
Mean		35.8	39.7	37.6	36	36.2	0.2

Lignin concentration did not significantly vary among species in five out of nine site-years or averaged over the nine site-years (Table 42). When lignin concentration varied among species, there was no consistent pattern for the species differences. The concentration of lignin was lower than would be observed for stored or conserved forages because they were harvested at the appropriate stage for grazing.

Table 42. Lignin concentration (%) of five annual forage crops harvested for simulated grazing and averaged over 2 or 3 harvests per year at 3 sites and 3 years in Saskatchewan.

Year	Site	Winter Triticale	Westerwolds ryegrass	Winter Wheat	Italian ryegrass	Winter rye	SE
2004	Swift Current	3.5	3.7	3.3	3.1	3.3	ns
	Saskatoon	2.5	2.6	2.4	2.7	3.7	ns
	Melfort	1.2	1.5	1	1.3	0.9	0.1
2005	Swift Current	2.4	2.3	2.4	1.9	2.4	0.1
	Saskatoon	6.6	6.2	5	6.9	7	ns
	Melfort	1.8	2.4	1.7	1.6	2.1	ns
2006	Swift Current	3.6	3.6	3.5	3.6	3.6	ns
	Saskatoon	3.9	4.6	3.6	5.8	3.5	0.2
	Melfort	2.6	2.7	2.8	1.9	3	0.1
Mean		3.1	3.3	2.8	3.2	3.3	ns

Economic Analysis

Five different species of winter annuals and forages were evaluated for grazing potential and economic suitability at three different locations across Saskatchewan (Swift Current, Saskatoon and Melfort). Saskatchewan Agriculture & Food's *Farm Machinery Custom and Rental Rate Guide* was used to determine operating costs in addition to the actual costs for all inputs. Revenue was calculated using Saskatchewan Agriculture & Food's ten year average market price for annual forages and based on the actual yields collected at the various locations. Total costs varied by management strategy at each location and included land preparation, inputs such as herbicide application and fertilization.

From these total cost and revenue values, a net return value was calculated for each species, at each location for each of the three years. In addition, a three year average net return was calculated for each species, at each of the three locations.

The economic results of the grazing potential at the Swift Current location are reported in Table 43. All five species realized a positive net return per acre at the Swift Current site for the 2004 and 2005 growing seasons; however in 2006 all five species experienced a negative net return per acre as yield was reduced by high temperature. The three year average net return per acre for these five species in a grazing system ranged between $8.64 per acre to $25.68 per acre, with Italian Ryegrass realizing the lowest net return and Winter Wheat attaining the highest net return per acre.

Table 43. Economic returns to five annual forage crops harvested for simulated grazing and at Swift Current for three years.

Species	2004 Net Return ($/ac)	2005 Net Return ($/ac)	2006 Net Return ($/ac)	Average Net Return ($/ac)
Winter Wheat	$67.69	$71.30	[illegible]	**$25.68**
Winter Triticale	$49.12	$48.60	[illegible]	**$13.13**
Winter Rye	$62.33	$57.57	[illegible]	**$21.64**
Westerwolds Ryegrass	$68.22	$57.42	[illegible]	**$20.84**
Italian Ryegrass	$41.32	$41.96	[illegible]	**$8.64**

The economic potential for the same five species at Saskatoon under a grazing system are shown below in Table 44. All species realized a positive net return in all three years at the Saskatoon location, with the exception of Italian Ryegrass in 2004, which ended the grazing season with a net loss of $17.53. Three year average net returns ranged from $25.87 per acre to $55.37 per acre. Similar to the results at Swift Current, Italian Ryegrass saw the lowest net return per acre, while Winter Wheat realized the highest net return per acre.

Table 44. Economic returns to five annual forage crops harvested for simulated grazing and at Saskatoon for three years.

Species	2004 Net Return ($/ac)	2005 Net Return ($/ac)	2006 Net Return ($/ac)	Average Net Return ($/ac)
Winter Wheat	$79.37	$88.69	$53.40	**$55.37**
Winter Triticale	$54.45	$76.11	$38.45	**$42.25**
Winter Rye	$60.03	$65.75	$18.40	**$36.05**
Westerwolds Ryegrass	$17.33	$82.99	$63.42	**$40.94**
Italian Ryegrass	($17.53)	$73.06	$47.96	**$25.87**

Melfort was the only location which registered positive net returns on all five forage species for each of the three years. The economic analysis for the Melfort location is shown in Table 45. All five species realized the largest net returns per acre at the Melfort location. The three year average net return ranged between $56.42 per acre and $81.45 per acre. In contrast to the other two locations, Winter Triticale resulted in the lowest average net return per acre, while Westerwolds Ryegrass had the largest average net return over the three grazing seasons.

Table 44. Economic returns to five annual forage crops harvested for simulated grazing and at Melfort for three years.

Species	2004 Net Return ($/ac)	2005 Net Return ($/ac)	2006 Net Return ($/ac)	Average Net Return ($/ac)
Winter Wheat	$83.11	$119.87	$75.14	**$69.53**
Winter Triticale	$59.73	$103.23	$62.70	**$56.42**
Winter Rye	$69.81	$132.68	$41.96	**$61.11**
Westerwolds Ryegrass	$122.08	$95.94	$107.76	**$81.45**
Italian Ryegrass	$82.75	$121.16	$66.49	**$67.60**

From an economic perspective, all five species have potential for producers to realize positive net returns when utilized in a grazing system at all three locations across Saskatchewan. The above data shows that Winter Wheat realized the highest net returns per acre when used in a grazing system for both the Swift Current and Saskatoon locations, whereas Westerwolds Ryegrass resulted in the highest net return per acre in a grazing system at the Melfort. While this information begins to shed light on the potential economic returns of the five species of winter annuals and forages examined when managed under a grazing system, it is essential that producers consider their own costs and potential returns prior to deciding to utilize any of these species within their grazing rotation.

Conclusions - Study 2

1. Westerwolds ryegrass produced the highest total pasture forage yield while Italian ryegrass produced the least.

2. Westerwolds ryegrass also produced the most regrowth (second and third cut) yield.

3. Winter triticale produced the highest CP concentration and lowest ADF and NDF concentrations when averaged over nine site-years and 2 or 3 harvests per site-year. However, the quality of Westerwolds ryegrass was sufficient to permit good gains by grazing cattle.

4. Winter wheat was the most profitable annual crops for grazing but followed closely by Westerwolds ryegrass. The least profitable annual crop was Italian ryegrass.

Acknowledgements
The technical assistance of Russell Muri, Tim Nelson, Cheryl Duncan, Brett Mollison, and Linden McFarlane was key to this project and gratefully acknowledged.